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HERITABILITY OF TRAITS OF THE TYPE LINEAR ASSESSMENT AND THEIR GENETIC ASSOCIATION WITH COW'S MILK YIELD OF UKRAINIAN DAIRY BREEDS

Leontii KHMELNYCHYI, Victoria VECHORKA, Anatolyi SALOHUB, Serhii KHMELNYCHYI, Igor RUBTSOV

Sumy National Agrarian University, Department of Animal Breeding and Selection and Aquatic Bioresources, 160, H. Kondratiiev St., Sumy, Ukraine, Emails: khmelnychy@ukr.net; vvvechorka@gmail.com; salogyb_a_m@ukr.net; serhiokh@ukr.net; rubtsov_igor@mail.ru

Corresponding author: khmelnychy@ukr.net

Abstract

The heritability of linear type traits and phenotypic correlations between them and milk yield of cows of Ukrainian Red-and-White (URW) and Black-and-White (UBW) dairy breeds was evaluated. Cows firstborn were estimated on the 100-point scale by such group traits: dairy type, body, limbs, udder and final score. 18 individual descriptive traits have been taken into account on a 9-point scale. By reliable significance confirmed sufficient degree of genetic determination group and most descriptive linear traits of URW cows (h^2 = 0.288-0.426 and h^2 = 0.161-0.422) and UBW (h^2 = 0.262-0.453 and h^2 = 0.128-0.434) testifying about feasibility and efficiency of mass selection dairy cattle by conformation. A reliable level (P <0.001) of positive correlation was determined between traits of dairy type URW and UBW (r = 0.412 and 0.468), body (r = 0.433 and 0.487) and udder (r = 0.453 and 0.474) and milk yield for 305 days of lactation. A reliable positive correlation was found between the final score and the yield value (r = 0.465 and 0.494). Lower correlation was found between limb condition and milk yield in URW and UBW cows, respectively (r = 0.122; P <0.01 and r = 0.205; P <0.001). Positive genetic association with milk yield was determined by the following descriptive traits of the type in URW and UBW, respectively: height (r = 0.312 and 0.278), body depth (r = 0.288 and 0.404), angularity (r = 0.504 and 0.486), rump width (r = 0.252 and 0.374), pelvic limb posture (r = 0.354 and 0.384), front udder attachment (r = 0.466 and 0.455), rear udder attachment height (r = 0.325 and 0.373), central ligament (r = 0.278 and 0.267) and locomotion (r = 0.286 and 0.275). A negative and reliable correlation was found between the trait of fatness (BCS) and yield, which was -0.366 and -0.389, respectively (P <0.001). Reliable correlation variability of group and most descriptive conformation traits with milk yield for the first lactation confirmed the possibility of unilateral breeding of dairy cattle by type.

Key words**:** *correlation, conformation traits, linear type estimation, Ukrainian Red-and-White dairy breed, Ukrainian Black-and-White dairy breed*

INTRODUCTION

The success of breeding in dairy cattle by conformation largely limited by degree of heritability - the relative proportion of genetic variability in the overall phenotypic diversity of body parts of conformation type such population. Since quantitative traits that have been determined by polymeric (additive) genes inherited by intermediate type, selection for them was significantly complicated. Linear traits of dairy cattle type belong to quantitative traits of polygenic heritability, so the efficiency of selection aimed at genetically improving the population of animals by conformation will largely depend on their degree of heritability (Burkat et al., 2004; Polupan, 2007; Dubin, 2006) [4, 6, 23].

Heritability coefficients have always been a mandatory component in determining selection indexes of breeding value. Their use in practical breeding allowed breeders faster will reach its goal, provided purposeful selection of animals according to indicators of conformation traits with high heritability coefficients (Burkat et al., 2004; Gritsenko, 2005) [4,10]. When calculating the heritability coefficient always determined only that portion of genetic variance, which was due to the additive effect of genes and the basis for all breeding programs. When conducting in-depth selection and breeding work, was necessary to clearly know the proportion of

genotype influence and environment on the formation of each trait - from the total variability of traits was necessary to exclude the impact of environment. Thus, the animal's genotype determined the body's response to environmental conditions, that is, not finished level of trait development, but the norm of genotype reaction to environmental conditions was inherited by descendants. Conditions have changed - the reaction norm will inevitably change. So, heritability has always manifested itself in specific conditions. Outside the environment, heritability is only an abstract concept.

Holstein Association USA experts believe that the heritability of 0.10 and below should not expect significant genetic progress. Heritability of individual and group traits of linear estimation Holstein breed cows for type according to their report (Linear type evaluations, 1999) ranging from 0.11 to 0.42, which gives reason to expect the possibility of effective selection for conformation [21].

Numerous studies of dairy cows estimated by linear classification method revealed a wide range of variability of heritability coefficients for group as well as by individual descriptive traits of the conformation. The width of variability spectrum of the values heritability coefficients of linear body parts of conformation and udder was recorded from quite low ($h^2 = 0.04$) to very high ($h^2 = 0.74$), depending on the influence of paratype factors, the degree of herd consolidation by conformation, efficiency of selection of bull-sires estimated by conformation type of their daughters, breed and method of calculation (Burkat et al., 2004; Furaeva, 2014; Shuklina et al., 2015; Boyko et al., 2015; Gritsenko, 2005; Eaglen et al., 2013) [3, 4, 7, 9, 10, 28].

The effectiveness of selection substantially depended on an equally important parameter of population genetics - correlation. About breeding importance of the association between linear traits of the conformation and milk productivity was well known from the research results. (Burkat et al., 2004) [4]. Breeding efficiency increasing significantly when there is a high degree of positive correlation between two traits. For example, between milk yield and height (r = 0.388) (Shevchenko, 2012) [27], rear posture (r = 0.349), rear width (r = 0.244) (Devyatkina et al., 2010) [5], attachment front udder parts (r = 0,38), teats length (r = 0.74) (Efimova et al., 2017)[8], body depth (r = 0.326) (Khmel'nychyi et al., 2017) [15], angularity (r = 0.377), pelvic limbs posture (r = 0.392), locomotion (r = 0.355) (Khmel'nychyi et al., 2012) [16], rear udder parts width (r = 0.30) (Smotrova et al., 2019) [29]. The situation changed if they dealing with two desirable traits, between which there was a negative correlation. For example, between milk yield and hoof angle (r = -0.40), central ligament (r = -0.06) (Efimova, et al., 2017) [8], udder depth (r = -0.47) (Eaglen et al., 2013) [7], body condition score (r = -0.211) (Khmel'nychyi et al., 2012) [16], rump position (r = -0.09) (Smotrova et al., 2019) [29]. In this case should lead the selection by two traits that will deter in some extent the effect of selection.

Given the importance of heritability of the conformation linear traits and their association with milk yield in the breeding system of dairy cattle of Ukrainian dairy breeds, we have been tasked to investigate these significant population-genetic parameters.

MATERIALS AND METHODS

Research were conducted in herds of breeding farms of Cherkasy and Sumy regions of Ukraine for breeding cows of Ukrainian Red-and-White (n=895) and Black-and-White (n=1,155) dairy breeds.

Cows firstborn were estimated using method of linear classification (Khmelnychyi et al., 2008) [13] according to the latest ICAR guidelines (Eaglen et al., 2013) [7] at the age 2-4 months after calving on two systems, 9-point, with a linear description of 18 conformation body parts, and a 100-point scale based on four groups of linear conformation traits.

The assessment on the 9-point scale consisted of linear description of 18 conformation body parts: animal height (AH), chest width (CW), body depth (BD), angularity (A), rear posture

(RP), rear width (RW), hock angle (HA), pelvic limb posture (PLP), hoof angle (HA), attachment front udder parts (AFUP), attachment height rear udder parts (AHRUP), central ligament (CL), udder depth (UD), front teats position (FTP), rear teats position (RTP), teats length (TL), locomotion (L), and body condition score (BCS). The average expression of trait was evaluated in five points, deviation in the direction of impairing development decreased the score (minimum number of points - 1), provided improving development of trait to the desired, the score increased to 9 points.

According to a 100-point classification system, the assessment was carried out visually, taking into account four complexes of breeding features characterizing: dairy type expression, body development, condition of limbs and morphological udder qualities. The complex of features included linear body parts that were functionally interconnected. Each conformation complex was estimated independently and had its own significant coefficient in the overall assessment of animals: dairy type (DT) - 15%, body (B) - 20%; limbs (L) - 25% and udder (U) - 40%.

The total type assessment was determined by the formula:

$$FS = (DT \cdot 0.15) + (B \cdot 0.20) + (L \cdot 0.25) + (U \cdot 0.40)$$

The coefficient of linear phenotypic correlation was determined by the Pearson formula:

$$r_{xy} = \frac{\Sigma(x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\Sigma(x_i - \bar{x})^2 \times \Sigma(y_i - \bar{y})^2}}$$

where: x_i – value for variable *X;*
y_i – value for variable *Y;*
$\bar{x}$ – average for *X;*
$\bar{y}$ – average for *Y.*

The heritability (h^2) of linear traits was evaluated as calculating the father's influence force indicator (η_x^2) in a one-factor variance complex (Plohinskij, 1964) [22] according to the formula:

$$h^2 = \eta_x^2 = \frac{C_x}{C_y}$$

where:
C_x – factorial variance;
C_y – total variance.

The reliability of obtained data was evaluated by calculating the errors of statistical values (*S.E.*) and Student's reliability criteria (td) for correlation analysis and Fisher (F) for variance analysis. The probability level was classified by comparison with standard criteria values. The results were considered statistically significant for the first – P <0.05 ([1]), the second – P <0.01 ([2]), and the third – P <0.001 ([3]) probability thresholds. Statistical processing of experimental studies was performed by the methods of mathematical statistics using formulas given by (Merkur'eva, 1970) [17] in Microsoft Excel.

RESULTS AND DISCUSSIONS

Determined values of heritability coefficients of the conformation traits of Ukrainian Red-and-White and Black-and-White dairy breeds were higher than in other studies (Salohub et al., 2010; Salohub et al., 2011; Furaeva, 2014; Bohlouli et al., 2015) [2, 9, 24, 25] (Table 1). Heritability coefficients of the conformation complexes of Ukrainian Red-and-White dairy breed did not significantly differ in the degree of variability and value compared to peers of Ukrainian Black-and-White. This was especially true of group traits that characterize dairy type of cows (h^2 = 0.435 and 0.453), udder (h^2 = 0.426 and 0.432), and final score (h^2 = 0.417 and 0.423). This level of additive genetic influence allowed obtain sufficient breeding effect as a result of animals selection on group linear traits of type.

Descriptive traits differed by higher variability, which ranged in animals of Ukrainian Red-and-White dairy breed from 0.154 (hoof angle) to 0.422 (angularity) and in animals of Ukrainian Red-and-White dairy cattle from 0.128 (udder depth) to 0.34 (angularity). The results obtained coincide with similar ones in the studies of dairy breeds of different breeding countries (Furaeva, 2014; Kern et al., 2014; Shuklina et al., 2015; Karymsakov, 2019) [9, 11, 12, 28].

At the same time, the obtained level of heritability coefficients for the most important traits, which positively correlated with milk yield (height, body depth, angularity, rump width, front and rear udder attachment, central ligament and locomotion), allowed to expect a selective improving effect of the conformation in the result of selection.

Table 1. Heritability (h^2) linear conformation traits of firstborn cows of Ukrainian Red-and-White and Black-and-White dairy breeds and their correlation (r) with milk yield for 305 days of lactation

Linear type traits	Ukrainian Red-and-White Dairy breed		Ukrainian Black-and-White Dairy breed	
	h^2	r	h^2	r
Traits that characterize: Dairy type	0.435[3]	0.412[3]	0.453[3]	0.468[3]
Body	0.321[3]	0.433[3]	0.294[3]	0.487[3]
Limbs	0.288[2]	0.122[2]	0.262[2]	0.205[3]
Udder	0.426[3]	0.453[3]	0.432[3]	0.474[3]
Final Score	0.417[3]	0.465[3]	0.423[3]	0.494[3]
Stature	0.337[3]	0.312[3]	0.365[3]	0.278[3]
Chest Width	0.241[3]	0.096[1]	0.279[3]	0.101[1]
Body Depth	0.311[2]	0.388[3]	0.282[2]	0.404[3]
Angularity	0.422[3]	0.504[3]	0.434[3]	0.486[3]
Rump Angle	0.268[3]	0.083	0.237[2]	0.082
Rump Width	0.286[2]	0.352[3]	0.251[2]	0.374[3]
Rear Legs Side view	0.161[1]	0.133[1]	0.131[1]	0.133[1]
Rear Legs Rear view	0.194[1]	0.354[3]	0.172[2]	0.384[3]
Hoof angle	0.154[1]	0.127[1]	0.133[1]	0.086
Front Udder Attachment	0.387[3]	0.466[3]	0.384[3]	0.455[3]
Rear Udder Parts Height	0.285[2]	0.325[3]	0.278[2]	0.373[3]
Central Ligament	0.277[2]	0.278[3]	0.285[2]	0.267[3]
Udder Depth	0.207[1]	-0.075	0.128	-0.084
Front Teat Position	0.277[2]	-0.212[2]	0.232[2]	-0.177[2]
Rear Teat Position	0.263[2]	-0.089[1]	0.217[2]	-0.135[1]
Teat Length	0.313[3]	-0.083	0.277[3]	-0.074
Locomotion	0.322[3]	0.286[3]	0.304[3]	0.275[3]
Body condition score	0.223[3]	-0.366[3]	0.235[2]	-0.389[3]

Note: [1] - $P < 0.05$; [2] $P < 0.01$; [3] $P < 0.001$
Source: Own calculations.

Lower heritability coefficients by descriptive traits that characterize limbs and level of their reliability in animals of evaluated breeds showed low efficiency of selection at this stage of breeding on these sufficiently substantive traits, which significantly influenced the duration of productive use of cows in industrial conditions (Zavadilová et al., 2009; Sawa et al., 2013; Khmel'nychyi and Vechorka, 2018) [14, 26, 30].

From the beginning of linear classification methodology, evaluation of cows by conformation type was based on the correlative variability of the development of individual body parts and group traits of the conformation with features of milk productivity, economic use, productive longevity, reproductive ability and health. The level and direction of association between type assessment and economically useful traits made it possible to navigate the

selection situation in the herd or breed, to determine the prospect of selection in order to improve the conformation of dairy cattle animals. These factors lead to numerous studies aimed at identifying such associations.
According to results of research found sufficient level for effective breeding of cows, of estimated URW and UBW breeds by type and a highly reliable level (P <0.001) of positive correlation between group traits characterizing dairy type of cows (r = 0.412 and 0.468), body development (r = 0.433 and 0.487) and morphological udder traits (r = 0.453 and 0.474) and milk yield per lactation. A significant positive correlation was also found between the final type score and the yield value (r = 0.465 and 0.494). A slightly lower correlation existed between limb condition and milk yield in URW and UBW cows, respectively (r = 0.122; P <0.01 and r = 0.205; P <0.001).
An important condition of ICAR (Ladyka et al., 2010) [19] is that each of approved linear traits should describe a unique cow body part that was not described in combination with other linear traits. These traits are called descriptive. The variability of correlations between the assessment of descriptive body parts and milk yield was significantly different from groups, but for most of them it was positive with high reliability.
Positive genetic association with milk yield was observed by the following conformation descriptive traits of estimated URW and UBW cattle: height (r = 0.312 and 0.278), body depth (r = 0.288 and 0.404), angularity (r = 0.504 and 0.486), rear width (r = 0.252 and 0.374), pelvic limbs posture (r = 0.354 and 0.384), front udder attachment (r = 0.466 and 0.455), rear udder attachment height (r = 0.325 and 0.373), central ligament (r = 0.278) and 0.267) and locomotion (r = 0.286 and 0.275). Negative and reliable correlation was found between the BCS trait (fatness) and milk yield, which was -0.366 and -0.389, respectively (P <0.001). The existence of a negative link between BCS (fatness) and milk yield has been reported in other studies on dairy cattle (Berry et al., 2004; Zink et al., 2014; Ladyka et al., 2017) [1, 18, 20, 31]. Thus, the genetic association of descriptive linear traits of the conformation with dairy productivity was one of the main factors for successful selection of dairy cattle.

CONCLUSIONS

The results obtained by linear classification of firstborn cows of Ukrainian Red-and-White and Black-and-White dairy breeds, reliable heritability coefficients of group and descriptive traits indicating about the perspective of efficiency animal selection by conformation.
Reliable positive correlation between group and most descriptive traits of linear classification and level of yield per lactation was determined in firstborn cows of the control breeds, indicating about effectiveness of breeding animals by conformation type, which will directly affect to increase their milk productivity.

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